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A catalogue of absorption-line systems in QSO spectra

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Abstract. We present a new catalog of absorption-line systems identified in the quasar spectra. It contains data on 821 QSOs and 8558 absorption systems comprising 16 139 absorption lines with measured redshifts in the QSO spectra. The catalog includes absorption-line systems consisting of lines of heavy elements, lines of neutral hydrogen, Lyman limit systems, damped Lyα absorption systems, and broad absorption-line systems. The catalog is available in electronic form at the CDS via anonymous ftp to *cdsarc.u-strasbg.fr* (130.79.128.5) or via http:// cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/412/707 and at *www.ioffe.ru/astro/QC*. Using the data of the present catalog we also discuss redshift distributions of absorption-line systems.

Key words. galaxies: quasar: absorption lines

1. Introduction

Absorption lines and absorption-line systems (ALSs) observed in the spectra of QSOs contain fundamental information on the distribution of matter between the observer and the QSO, and on physical processes in the Universe in different epochs of the cosmological evolution. To date, thousands of ALSs have been identified and their number grows persistently, scattered over numerous sources. This stimulates the creation of catalogs of ALSs comprising the most complete data on the absorption lines and their systems.

Catalogs of ALSs have been compiled many times. We mention the early catalogs of Perry et al. (1978) and Ellis & Phillips (1978), and the later vast QSO catalogs of Hewitt & Burbidge (1980, 1987, 1989, and 1993) which include also data on the ALSs detected in the QSO spectra. Junkkarinen et al. (1991) and York et al. (1991) created special ALS catalogs most complete for that time. The new generation of telescopes (Keck, VLT, etc.) has yielded a great amount of new spectroscopic data. Some have been collected in special catalogs including either the results of certain spectral investigations or the definite types of ALSs (e.g., Lyman limit systems – LLS, damped Lyα absorption systems – DLA, broad absorption-line systems – BAL, etc.). For example, the catalog by Outram et al. (2001) of the ALSs detected in the 2dF QSO Redshift Survey or the catalogue of DLAs compiled by Curran et al. (2002). However, as far as we know, there are no modern catalogs comprising comprehensive data on the ALSs registered to date.

Our new catalog is an attempt to collect the basic information on the ALSs in QSO spectra. The data are taken from publications available up to January 2002. The catalog includes, in particular, all the data of the catalogs of Junkkarinen et al. (1991) and York et al. (1991). The catalog consists of introduction (ReadMe), Tables 1 and 2, and list of references, which are available in electronic form at the CDS and at *www.ioffe.ru/astro/QC*.

2. Description of the catalogue

Table 1 (*Quasars*) contains data on 821 QSOs whose characteristics of spectral observations are collected in Table 2. The QSO data are based on the catalog of Veron-Cetty & Veron (2001). The following information on the QSOs is given: the QSO's name (J2000) identical to the name in Table 2 (see below) and the name given in the catalog of Veron-Cetty & Veron (2001); equatorial coordinates at 2000 and 1950, right ascensions α_{2000} and α_{1950}, and declinations δ_{2000} and δ_{1950} in the order of increasing right ascensions; emission-line redshift $z_{\rm em}$; apparent magnitude V; absolute magnitude M.

Table 2 (*Absorption systems*) contains the following information on spectral observations of the QSOs and on the detected ALSs:
(i) the name of QSOs (J2000 and Q1950) which spectral observations are presented in literature,
(ii) *parameters of spectral observations* (see below),
(iii) *characteristics of absorption lines* combined in the systems.

The *parameters of spectral observations* of 821 QSOs contain the following data: the interval of wavelengths (Å) covered by the cited observations; spectral resolution

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$R = \Delta\lambda_{\rm obs}$ (Å); signal-to-noise ratio $\langle S/N \rangle$, averaged over the entire spectral interval of observations; in some cases, the threshold (minimal) value of the absorption equivalent width in Å ($W_{\rm min}$ or $W_{\rm rest,min}$ the observer or the rest reference frame) used by the cited authors as the criterion of line detection; the emission-line redshift $z_{\rm em}$; references.

Table 2 includes the *characteristics of* 16 139 *absorption lines* detected in the spectra of 735 QSOs. These lines form 8558 absorption systems. In the spectra of 14 QSOs only Galactic interstellar lines have been detected; characteristics of these lines are excluded. In the spectra of 72 QSOs the absorption lines have not been detected or identified. Table 2 comprises 3039 absorption-line systems including lines of heavy elements. For instance, we present 2871 resonance doublets of ions Mg II, Al III, C IV, Si IV, N V, and O VI. The table comprises also 6063 systems containing lines of neutral hydrogen (HI). In particular, there are 5554 systems including only lines of HI, 146 LLSs, 195 DLA systems, and 39 BAL systems. LLSs are optically thick at the HI Lyman limit (912 Å). They correspond to HI column densities $N({\rm HI}) > 2 \times 10^{17}$ cm^{-2}. DLA systems correspond to high HI column densities N(HI) $> 2 \times 10^{20}$ cm^{-2}. BAL systems are characterized by wide absorption troughs produced by ions with an outflow velocity extending up to 60 000 km/s relative to the QSO's. We rule out absorption systems consisting only of one heavy-element absorption line.

The data are listed in the order of increasing absorption-system redshifts. For heavy-element and HI systems we present the following information: the absorption-system redshift $z_{\rm abs}$, name of the ion identified, laboratory wavelength $\lambda_{\rm lab}$ in Å, observed wavelength $\lambda_{\rm obs}$ in Å, error $\sigma(\lambda_{\rm obs})$ of the value $\lambda_{\rm obs}$ at 1σ significance level, absorption-line equivalent width $W_{\rm obs}$ (Å) (measured in the observer frame) or column density of the ion $\log N$ (cm^{-2}), error $\sigma(W_{\rm obs})$ (or $\sigma(\log N)$) of the values $W_{\rm obs}$ or $\log N$ (cm^{-2}), respectively. For the LLSs we give only the redshift $z_{\rm abs}$ of the absorption edge (912 Å). For the DLA systems we present: $z_{\rm abs}$, the observational equivalent width $W_{\rm obs}$ (Å) or HI column density $\log N$(HI) (cm^{-2}). For the BAL systems: the averaged value of $z_{\rm abs}$, names of identified ions, width of the trough ($\Delta z_{\rm abs}$).

Table 2 contains also a few sets of observational data on spectra of the QSOs registered in different observations and presented by different authors. Special signs indicate the cases where absorption lines are blended by unidentified lines.

All relevant notations and comments for users are given in the introduction (ReadMe). The list of references contains literature sources quoted in Table 2.

The authors are planning to replenish the catalog regularly. Any remarks and comments would be greatly appreciated.

3. Redshift distributions

All absorption-line systems collected in the catalog belong to the redshift interval from $z_{\rm min} = 0.0033$ to $z_{\rm max} = 4.93$. As an illustration, we compare (Fig. 1) two z-distributions of the absorption systems including heavy-elements lines within the redshift interval $z = 0$–3.7. One of them is obtained using the data of the catalog of Junkkarinen et al. (1991) and the other is based on the present catalog. In accordance with the data of Junkkarinen et al. (1991) all absorption redshifts fallen within an interval of 500 km s^{-1} are treated as a single system with a single $z_{\rm abs}$. We have compiled 2003 absorption systems versus 847 systems from the catalog of Junkkarinen et al. (1991). Both distributions are obtained using the so-called sliding-average approach, in which a set of consecutive displacements of the averaging bin $\Delta_{\rm z} = 0.071$ is performed along the z axis with the step $\delta_{\rm z} = 0.01$.

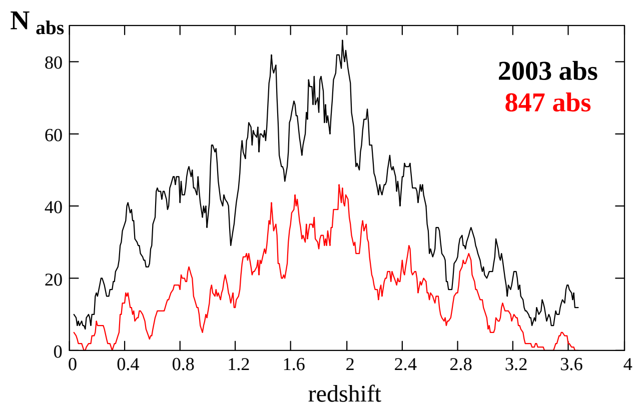

Fig. 1. Two z-distributions of absorption systems observed in QSO spectra containing heavy-elements lines within the redshift interval $z = 0$–3.7: 847 systems are obtained from the data of Junkkarinen et al. (1991) and 2003 systems are obtained from the present catalogue (see text).

As shown by Ryabinkov et al. (2001) from the data of Junkkarinen et al. (1991) the z-distribution of absorption-line systems displaces a pattern of alternating maxima (peaks) and minima (dips) relative to a smooth curve. It is essential that their positions turn out to be independent of observation directions. Additionally, the data revealed a regularity (sort of periodicity) of the distribution with respect to some rescaled functions of z. This suggests that the derived distribution of absorption matter is not only spatial but also temporal in nature. A comparison of the two z-distributions (Fig. 1) indicates that the positions of all main peaks and dips remain the same after the expansion of statistics some of them are now more significant.

These conclusions confirm the results of earlier statistical analyses (Ryabinkov et al. 1998 and Kaminker et al. 2000) of z-distributions of C IV and Mg II absorption systems. Detailed statistical analysis of such distributions based on the present catalogue will be done elsewhere.

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